REVIEWS

MOORE'S ECONOMIC CYCLES

IN this volume[1] Professor Moore again makes use of his characteristic method, developed in his earlier volume on *Laws of Wages*. The method, in brief, is to derive economic laws inductively from statistics by means of the modern refined methods of the calculus of probabilities. The specific problem in the present instance is to derive the law of business cycles of expansion and depression from data as to rainfall, crops, and prices.

First, by an application of Fourier's formula to data as to rainfall in the Ohio valley and in Illinois, he finds that the annual rainfall obeys a compound cyclical law based on cycles of eight and thirty-three years. He then correlates the rainfall at the critical period of growth for each crop with the total yield and with the yield per acre of the principal staple crops. These in turn are correlated with prices of pig iron and with general prices. The laws which he derives from this analysis may be briefly stated as follows. The annual rainfall, as just stated, obeys a law of compound cycles of eight and thirty-three years' duration. The yield of the great staple crops, both the gross yield and the yield per acre, obeys a similar law, presumably in the relation of cause and effect. The upward phase of a period of agricultural productivity brings with it, allowing a lag of a few years, a period of general business expansion, characterized by an increased demand for producers' goods (of which pig iron may be taken

[1] Economic Cycles: their Law and Cause. By Henry Ludwell Moore. New York, The Macmillan Company.

The reviewer wishes to acknowledge his indebtedness to Sewall G. Wright for valuable suggestions, and assistance in making the computations involved in preparing this review.

as typical), increased employment of labor, an increased demand for all kinds of goods, and a consequent rise in general prices. This process is arrested when the cycle of agricultural productivity begins its downward phase; and a reverse series of phenomena then appears. In the author's words: "These cycles of crops constitute the natural, material current which drags upon its surface the lagging, rhythmically changing value and prices with which the economist is more immediately concerned."[1]

As a necessary step in the logical course of his argument, Professor Moore also makes some interesting studies in demand curves. From tables of the output and prices of certain staple goods he constructs a percentage demand curve by making the abscissas proportional to the percentage change in output for each year above or below the output for the preceding year (each preceding year being successively used as a base), while the ordinates are made proportional to the corresponding changes in prices, similarly computed. From this exploration he emerges with what he appears to regard as a surprising discovery, namely, the discovery of a new type of demand curve. "Our representative crops and representative producers' good exemplify types of demand curves of contrary character. In one case, as the product increases or decreases the price falls or rises, while, in the other case, the price rises with an increase of the product and falls with its decrease."[2] In connection with this discovery he treats somewhat patronizingly the whole *ceteris paribus* type of reasoning of his predecessors. The universal, negatively inclined demand curve of Professor Marshall is characterized as "an idol of the static state." The fruitfulness of the statistical method is contrasted with the "vast barrenness" of the conventional method.

Take, for example, the question of the effect of the weather upon crops. What a useless bit of speculation it would be to try to solve, in a hypothetical way, the question as to the effect of rainfall upon the crops, other unenumerated elements of the weather remaining constant! The question of the effect of temperature, *ceteris paribus!* How, finally,

[1] Page 149. [2] Page 114.

would a synthesis be made of the several individual effects? The statistical method of multiple correlation formulates no such vain questions. It inquires, directly, what is the relation between crop and rainfall, not *ceteris paribus*, but other things changing according to their natural order; what is the relation between crop and temperature, other things conforming to the observed changes in temperature; and, finally, what is the relation between crop and rainfall for constant values of temperature?[1] The problem of the effects of the constituent factors is solved only after the more general problem has received its solution. This method offers promise of an answer to the question as to the relation between the effective demand price and the supply of the commodity.[2]

A valuable feature of Professor Moore's work is the insertion of the tables of statistics upon which his argument is based. This enables the reader, if so inclined, to check or supplement the reasoning. Numerous periodograms and examples of demand curves also illustrate the subject matter.

There can be no difference of opinion as to the great value of Professor Moore's method. He is doing pioneer work and is doing it with painstaking detail and thoroness. The more economic theory can be reduced to the status of an exact science, the more serviceable will it become in bringing to finer order and adjustment our intricate and highly organized modern life. It is, therefore, with diffidence that I approach the task of criticizing a book involving at once such keen mathematical insight and such immense industry in laborious detail. Yet, to me, it falls short of conclusiveness. Several links in the logical chain seem to need closer scrutiny.

In the first place, the alleged discovery of an eight-year cycle is suspicious. It certainly does not harmonize with data relating to industrial crises. These are known to follow more nearly a ten-year cycle. Now an eight-year cycle, however adjusted to the dates usually given for crises, would bring some at a period of high prices, some at a period of low prices, and some at intermediate points. It is clear, then, that if Professor Moore's economic cycles are real, they

[1] The full multiple correlation here suggested is not, however, carried out in the text.

[2] Pp. 67, 68.

represent a phenomenon disconnected with the well known phenomenon of industrial revulsions. This discrepancy led me to undertake an independent study of the data.

It was first observed that the eight and thirty-three year cycles were derived from data as to *annual* rainfall, while the whole argument rests upon the *effective* rainfall at the critical periods of growth of the several crops considered. Professor Moore fails to correlate these two. Perhaps he may have regarded it as safe to assume that if the annual rainfall follows an eight-year cycle, the same would be true of effective rainfall. Yet while a study of the data for annual rainfall reveals a fairly well marked cycle of eight years with an amplitude of 4.13 (p. 24), the periodograms for effective rainfall (pp. 46, 47, 48, 54) show only a very minor indication of an eight-year cycle (amplitudes, 0.21, 1.71, 0.21, 0.24). There is more indication of a four-year cycle (amplitudes, 1.22, 1.39, 1.22, 0.40). The periodograms give the same impression to the eye. Now, later in the text, when general prices are correlated with crops, a lag of four years is allowed to give time for the crops to show their effect in prices. If the cycle of rainfall is four years and if rainfall is the efficient cause of fluctuation in crops, clearly a lag of four years is meaningless — prices could hardly be one full cycle in advance of their efficient cause.

Still, there might be a mean effective rainfall cycle of longer period than four years, but not necessarily eight, which would account for the high correlation between crops and prices noted later in the text. To investigate for such a cycle the following method was employed. It is confessedly less exhaustive than Professor Moore's method of amplitudes but is believed to be fairly conclusive — at least, sufficiently conclusive to form the basis of a working hypothesis. If a series of numbers be given, then by means of the formula,[1]

$$r_{xx} = 1 - \frac{1}{2}\,\frac{\sigma_\nu{}^2}{\sigma_x{}^2}$$

[σ_ν = standard derivation of the differences.]

[1] This formula is given in " A short method of calculating the coefficient of correlation in the case of integral variates." J. A. Harris. Biometrica, vol. vii, p. 214.

each number in the series may be correlated with its adjacent, its second, its third, its fourth, etc. If the series conceals a true cycle, it will be revealed by this process. For, suppose the cycle to be one of eight years, then when each number is correlated with its eighth, we shall have a high positive correlation, approaching unity. When each number is correlated with its fourth, the result will be a high negative correlation; with its second and sixth, approximately 0; with its adjacent and seventh, a low positive, and with its third and fifth, a low negative correlation. In other words, if there be a true cycle, the application of this method will reveal a cycle of correlations. If a short cycle were superposed upon a larger one, it might well happen that all the correlations would be positive for the minor cycle. Even then there would be a cycle of these positive correlations with respect to magnitude, as is shown in the case of crops. See footnote.

An application of this method to mean effective rainfall failed to give evidence of an eight-year cycle, but did give some evidence of a seven-year cycle, and possibly also of a cycle of between three and four years. The same method applied to data of yield per acre of nine principal crops gave good evidence of a seven-year cycle, but when applied to prices a well-marked cycle of nine years was revealed.[1] These results were checked by constructing historigrams from the data and observing the intervals between successive maxima and minima. Now it is to be noted that in the case of general prices the correlation of each number with its tenth is nearly as high as with its ninth, and a study of the historigram (Fig. 1) reveals points of maxima at 1873, 1883, 1893,

[1] Mean effective rainfall: $r_1 = -0.138$, $r_2 = -0.174$, $r_3 = 0.063$, $r_4 = 0.199$, $r_5 = -0.311$, $r_6 = 0.035$, $r_7 = 0.330$, $r_8 = -0.095$.

Crops; $r_1 = 0.280$, $r_2 = 0.261$, $r_3 = 0.114$, $r_4 = 0.110$, $r_5 = 0.120$, $r_6 = 0.146$, $r_7 = 0.491$, $r_8 = 0.171$.

General prices; $r_1 = 0.600$, $r_2 = 0.380$, $r_3 = -0.260$, $r_4 = -0.525$, $r_5 = -0.310$, $r_6 = -0.330$, $r_7 = -0.034$, $r_8 = 0.201$, $r_9 = 0.401$, $r_{10} = 0.348$.

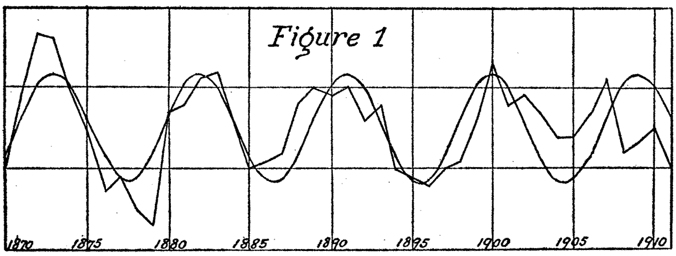
It must be confessed that the figures in the case of mean effective rainfall are very inconclusive. The negative result ($r_1 = -0.138$), when each number is correlated with its adjacent, makes it questionable whether there is any true cycle. The positive correlation ($r_7 = 0.330$), when each number is correlated with its seventh, may be due to mere chance.

and 1907. All of these points are followed by a sharp decline and the dates are those associated with industrial crises. This is certainly suggestive. The other point of maximum is at 1900. There was a crisis in 1903, but here the connection is not so close. The crisis of 1903 appears to have fallen during a decline in prices instead of immediately preceding it. A nine-year periodogram is fitted to the crude data, as shown in the figure. The closeness of the fit is striking.

An apparently strong argument for Professor Moore's theory is found in the high correlation between the yield of crops per acre and general prices, after allowing for a lag of four years. This is surprising, since, from what has been said in the preceding paragraph, the periods appear to be different — one seven years and the other nine or ten years. But an inspection of the historigrams (p. 123) reveals the probable cause of this high correlation. In both cases the minor cycles are superposed upon a larger cycle (possibly Professor Moore's thirty-three year cycle).[1] In the case of crops there is a distinct downward trend from 1870 to about 1892, and from there upward to 1910. In the case of general prices the downward trend extends from 1870 to about 1896 and thence upward to 1910. Hence if a lag of four years be allowed (or even without it), a high correlation would be shown because of these general trends, even if there were no correlation whatever from the minor cycles. I tried the experiment of eliminating these general trends and obtained the following results. Lag of four years, $r = 0.353$; three years, $r = 0.341$ two years, $r = 0.184$; one year, $r = 0.026$. The first of these results, tho much smaller than Professor Moore's ($r = 0.800$), is still striking. The experiment was tried of holding the two historigrams up to a window, one superposed upon the other, and then sliding one upon the other so as to accord with a lag of four years. The crops showed one more complete cycle than the prices in the interval from 1870 to 1910, but, the cycles constructed from the crude data being

[1] Tho in the case of general prices this would be complicated with the effect of changes in the world's gold supply. It would be necessary to apply the method of multiple correlation to eliminate this effect.

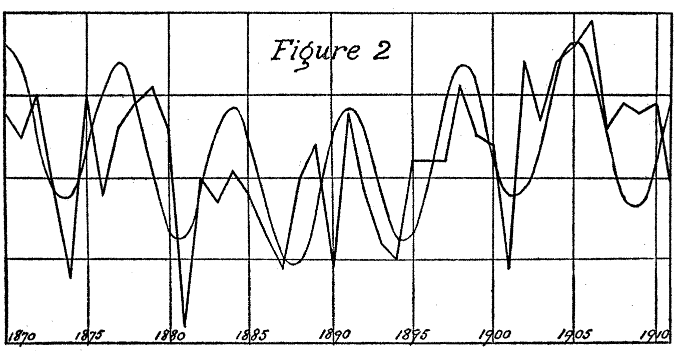
confessedly irregular, there was a rather surprising congruence in some parts of the two historigrams.[1] Whether this congruence is to be accounted for by rainfall or by accident can be determined only by data extending over a longer period of time. The historigrams referred to in this paragraph, with accompanying periodograms, are shown in Figures 1 and 2. In the case of general prices the trends have been eliminated. In the case of crops they have been accounted for by assuming a thirty-three year cycle.



General Prices: Nine-Year Cycle.

Equation; $y = 15.1 + 6.7 \sin \left(\frac{2 \pi t}{9} + 330.6°\right)$.

General trends from 1870 and 1910 to 1896 eliminated.



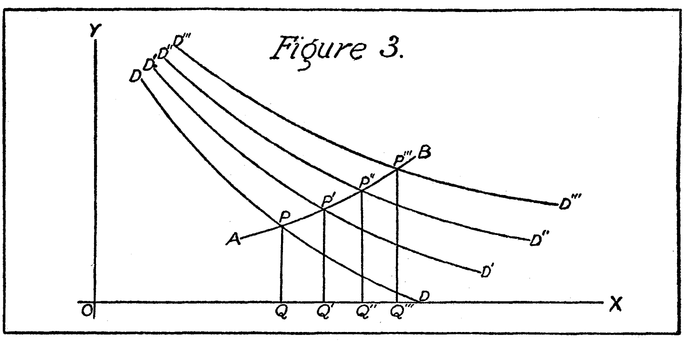
Annual Yield of Nine Crops: Seven and thirty-three Year Cycles.

Equation; $y = 102.6 + 4.33 \sin \left(\frac{2 \pi t}{33} + 77.3°\right) + 9.34 \sin \left(\frac{2 \pi t}{7} + 88.3°\right)$.

[1] This crude visual test is only introduced as suggestive. Needless to say, it falls far short of conclusiveness.

In conclusion of this phase of the subject the suggestion is offered that before any cycles relating to rainfall can be regarded as conclusive, some adequate astronomical or meteorological cause should be adduced.

Professor Moore's studies in demand curves illustrate the principle that the need of checking statistical inductions by abstract reasoning is quite as great as that of verifying abstract reasoning by statistics. The demand curves for crops harmonize perfectly with theory: the conditions of demand remain approximately constant; there is an increased output of crops (very probably due to heavier rainfall); with the diminishing utility due to this increased supply, the marginal utility and hence the price falls. But how about the "new type," the ascending demand curve for pig iron, is it so hopelessly irreconcilable with theory? Not at all. The conditions of demand are changed (very probably by improved business conditions) in the direction of a rapid and continuous increase. This would be indicated, conformably to theory, by shifting the entire demand curve progressively to the right. The ordinates to this shifting curve, corresponding with the lagging supply, will yield Professor Moore's "new type." Thus (see Figure 3):



D, D', D'', etc., represent the conditions of increasing demand. OQ, OQ', OQ'', etc., the corresponding lagging supply. PQ, $P'Q'$, $P''Q''$, etc., the marginal utilities (and hence prices) corresponding with these supplies, and AB the "new type" of demand curve.

The above explanation is essentially that made by Professor Moore himself when he comes to interpret the results of his statistical analysis. The only point here made is the necessity of having a consistent body of theory to interpret just such results as that of the pig iron demand curve. Suppose, for example, we were to accept as universal the inductive law of producers' goods given on page 114. "The price rises with an increase of the product and falls with its decrease"; and suppose, furthermore, that manufacturers of pig iron on the strength of this "universal law" should deliberately double, treble, or quadruple their output in the confident expectation that prices would rise proportionately: I fear that thereafter Professor Moore would not stand high as a prophet among producers of pig iron.

An interesting by-product of the analysis is found in the possibility of predicting prices of the great agricultural staples for any year from estimates as to yield. As already explained the demand curves were constructed by first plotting as abscissas and ordinates the crude data representing the percentage in change in yield and price for each year as compared with the preceding year, and then fitting the best "skew" to the crude data so plotted. The prediction of prices for staple crops is a matter of no little practical importance, especially to large dealers and speculators in futures. To such Professor Moore's method may prove serviceable. May I venture to suggest a slight improvement in respect to the selection of a curve? Professor Moore uses the cubic, $y = a + bx + cx^2 + dx^3$. Now there is no *a priori* reason why the demand curve should assume the form of a cubic. There is no reason to suppose that the demand curves for corn, hay, oats, and potatoes change their elasticity in the curious ways shown near the extremities of the curves on pages 73, 74, 75, and 76.[1] These peculiarities arise simply

[1] Professor Marshall (Principles of Economics, p. 161) holds that for "nearly all commodities" the elasticity of demand is greater for the middle range of prices than for prices either very high or very low. This principle might seem to justify the use of a cubic when it takes the form shown in the demand curve for corn (Fig. 4). But it is quite as likely to take the form shown in the demand curve for oats (Fig. 5). This would illustrate a precisely opposite principle, — indeed it shows a condition at its extremities which is obviously absurd.

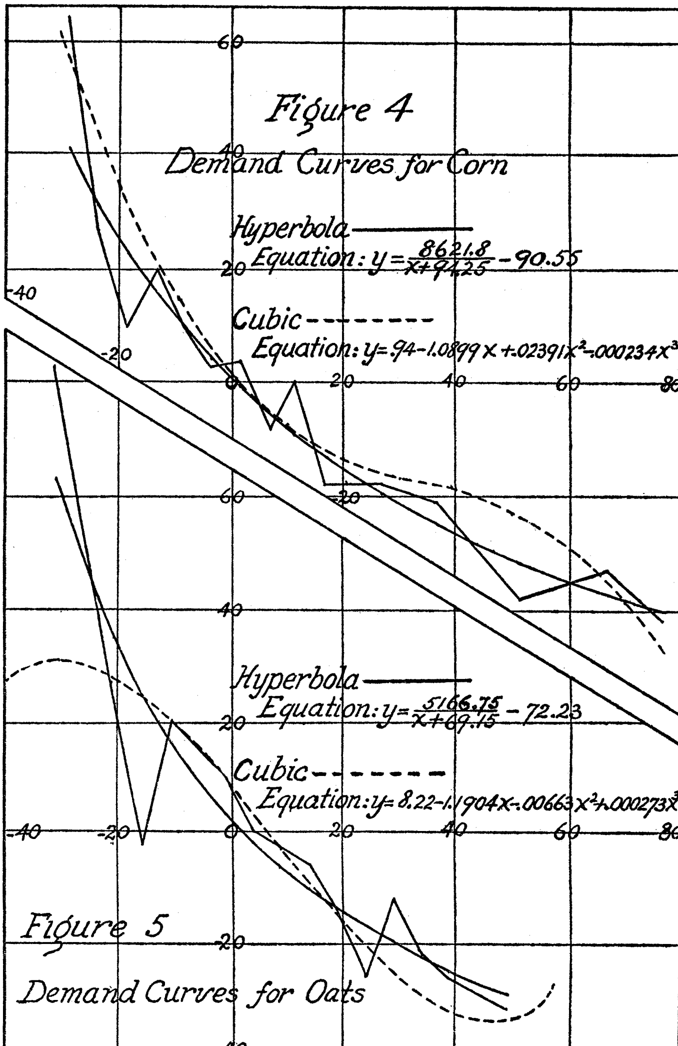


Figure 4
Demand Curves for Corn
Hyperbola
Equation: y = 8621.8 / (x+94.25) − 90.55
Cubic
Equation: y = .94 − 1.0899 x + .02391x² − .000234x³
Figure 5
Demand Curves for Oats
Hyperbola
Equation: y = 5166.75 / (x+69.15) − 72.23
Cubic
Equation: y = 8.22 − 1.1904x − .00663x² + .000273x³
60
40
20
0
-20
-40
20
40
60
80

from the fact that a point of inflection is a property of the cubic. On the other hand there is some slight *a priori* ground for supposing the demand curve to be of the hyperbola type, a curve without points of inflection. In the case of the value of money, it can be demonstrated that the demand curve is the equilateral hyperbola. As Karl Pearson has pointed out, the problem in curve-fitting lies quite as much in the selection of the right type of curve as in the fitting of it to the data when selected.[1] Accordingly the experiment was tried of fitting equilateral hyperbolas to the data for the above mentioned staple crops. The method of moments was employed, the method of least squares being inapplicable. The results obtained in the case of corn and oats are shown in Figures 4 and 5.

In conclusion it is fair to say that Professor Moore's volume is most suggestive and stimulating. Yet it may be questioned whether the main contention of business cycles based upon rainfall is fully proved. As they say in legislative bodies, it would perhaps be best to "refer the whole matter back to the committee for further study."

PHILIP G. WRIGHT.

HARVARD UNIVERSITY.

[1] "Thus, in fitting an empirical curve to observation it is all important to make a suitable choice of that curve, that is, to determine whether it should be algebraic, exponential, trigonometric, etc." — On Systematic Curve Fitting, Part II. Biometrica, vol. ii, p. 16.